RELATIVE VULNERABILITY TO EXTIRPATION OF MONTANE BREEDING BIRDS IN THE GREAT BASIN

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Abstract.—Seventy-four species of montane breeding birds were evaluated for their vulnerability to extirpation in the Great Basin. Although none of these species are endemic to the Great Basin, the montane island system results in a unique pattern of species associations. Loss of species from these montane communities could be indicative of region-wide habitat degradation. I ranked susceptibility to extirpation based on seven biological variables: geographic range, population size, reproductive potential, susceptibility to cowbird parasitism, migratory status, and diet specialization. Each variable was weighted equally in its contribution to vulnerability, and scores were the sum of trait scores for each species. Different suites of life-history traits led to similar vulnerabilities. The following 10 montane bird species were categorized as most vulnerable to extirpation from the Great Basin, listed as most to least vulnerable: Olive-sided Flycatcher (*Contopus borealis*), Painted Redstart (*Myioborus pictus*), Hammond's Flycatcher (*Empidonax hammondii*), Veery (*Catharus fuscescens*), Whip-poor-will (*Caprimulgus vociferus*), Lincoln's Sparrow (*Melospiza lincolnii*), Black-backed Woodpecker (*Picoides arcticus*), Three-toed Woodpecker (*P. tridactylus*), Himalayan Snowcock (*Tetraogallus himalayensis*), and Nashville Warbler (*Vermivora ruficapilla*). Species of similar vulnerability scores often were dissimilar in threats related to their vulnerability. No taxonomic patterns in vulnerability were found. This type of analysis should be used proactively to identify vulnerable species or populations and to set priorities for research and management.

Key words: vulnerability, conservation priorities, avian diversity, Great Basin, montane islands.

Extinction of species worldwide is occurring at a high rate (Stanley 1985). For the most part, species disappear following habitat loss (Ehrlich 1988) or after stochastic events eliminate relatively small or isolated populations (MacArthur and Wilson 1967, Shaffer 1981, Gilpin and Soulé 1986, Rabinowitz et al. 1986, Reed 1990). Because time, money, and other resources for species preservation are in short supply, it is imperative to identify the relative susceptibility to extinction, or extirpation, among species to aid in setting conservation and management priorities.

Extremely vulnerable species often are easy to identify because of their scarcity, although sometimes they might be difficult to verify as extant (Solow 1993). Slightly more common species, however, often are difficult to classify by their relative susceptibility to extirpation even if it varies greatly among species (Rabinowitz 1981, Rabinowitz et al. 1986, Reed 1992). Methods that discriminate among species' susceptibility to extirpation would be valuable for setting management priorities. Such methods exist for selecting geographic areas for conservation based on the number or variety of species present (e.g., Kirkpatrick 1983, Margules and

Usher 1984, Miller et al. 1987, Scott et al. 1991), but these methods are not applicable to prioritizing conservation efforts among species.

Economic methods can be used to prioritize conservation efforts (Bishop 1978, Hyde 1989), but they do not accommodate non-monetary appraisals of wildlife conservation goals (Sagoff 1988). The triage method (Myers 1979), whereby species are divided into three categories based on likely success of conservation efforts, might not protect the species that are biologically or anthropocentrically the most important. In the present analysis, I used biological traits to determine the relative susceptibility among species to extirpation.

I analyzed susceptibility to extirpation (local extinction) of bird species breeding in the semi-isolated montane habitats of the Great Basin. This is a classic island-biogeographic system that has been used to test ideas about extinction and colonization processes (e.g., Brown 1971, 1978, Johnson 1975, 1978, Behle 1978, Wilcox et al. 1986, Britton et al. 1994). Although there are no endemic bird species in the Great Basin, loss of species from these montane communities reduces biodiversity and could be indicative of region-wide problems.

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Furthermore, the naturally fragmented habitat of the Great Basin montane forest can act as a model for human-caused fragmentation occurring throughout the world. The 74 species considered here differ greatly in their life histories, abilities to colonize, and susceptibility to extirpation. My goal was to rank species by biological characteristics related to their vulnerability to extirpation, in the anticipation that the information would be useful for setting priorities for research, conservation, and management.

Assessing susceptibility to extirpation involves some type of decision analysis (sensu Maguire et al. 1987). There are many methods available for assessing susceptibility to extirpation, and they vary in complexity from simple classifications to complex multivariate analyses (Table 1). More importantly, classification methods differ in their data requirements. Some systems, such as the IUCN classification scheme (Mace and Lande 1991), are data intensive, while others require far less data (Table 1). The more data available for decision making, the more certain the results, but it is important to chose a method that makes proper use of the available data. Biological data are relatively scarce for birds in the Great Basin. In this analysis, I used a method with intermediate data needs to look at vulnerability to extirpation of 74 montane breeding bird species.

METHODS

I combined the methods of Burke and Humphrey (1987), Millsap et al. (1990), and Rabinowitz et al. (1986) to develop an analysis appropriate for the species and available data. This analysis involved assessment using seven biological characteristics related to persistence ability. Values for each characteristic ranged from 0 to 1, with higher values associated with higher susceptibility to extirpation. Values for each character were summed to arrive at a final score of susceptibility to extirpation from the Great Basin. All variables had the same range so that no single character contributed disproportionately to the susceptibility score (Given and Norton 1993). Himalayan Snowcock and Ruffed Grouse (scientific names are given later) are introduced species in the Great Basin (Alcorn 1988). They were included in the analysis because they are established in the Great Basin avifauna. Variable descriptions used in scoring vulnerability to loss from the Great Basin follow.

Geographic range.—Species distributions were taken from a subset of 20 montane sites from the Great Basin (Johnson 1975). The contribution of this variable to the vulnerability score was calculated as 20 minus the number of ranges on which the species occurs, divided by 20. This results in a value ranging from 0 to 1.0, with higher values associated with fewer ranges occupied by the target species, i.e., greater vulnerability. Mountain ranges here and in Table 2 are numbered the same as in Johnson (1975): 1–Warner, 2–Pine Forest, 3–Santa Rosa, 4–Jarbidge, 5–Raft River, 6–Desatoya, 7–Toiyabe-Shoshone, 8–Ruby, 9–Spruce–S. Pequop, 10–Deep Cr.–Kern, 11–Snake, 12–White–Inyo, 13–Plametto, 14–Grapevine, 15–Panamint, 16–Spring, 17–Sheep, 18–Mt. Irish, 19–Quinn Canyon–Grant, and 20–Highland. Distributional data were supplemented from Behle (1978), Herron et al. (1985), Ryser (1985), Alcorn

TABLE 1. Methods for assessing susceptibility to extirpation and for scoring conservation priorities.

Method	Data intensity	Analysis complexity	Citations
Anthropocentric	low	very low	the history of the world
Decision analysis:			
contingency	low	low	Rabinowitz 1981, Rabinowitz et al. 1986, Kattan 1992, Reed 1992
ordinal	variable	low	Burke and Humphrey 1987, Millsap et al. 1990, this study
classical	variable	medium	Maguire et al. 1987
multivariate	variable	high	Given and Norton 1993
Economic	variable	variable	Bishop 1978, Hyde 1989
Viability analysis	high	high	Kinnaird and O'Brien 1991, Boyce 1992
IUCN	very high	high	Mace and Lande 1991

TABLE 2. Additions to Johnson's (1975) original bird distributions. Site numbers are the same as those used by Johnson (1975) and are listed in Methods. Scientific names are listed in Table 3.

Species	Sites added
American Wigeon	S[A]
Northern Goshawk	3[H], 5[B], 7[H], 10[B], 25[H], 30[B]
Sharp-shinned Hawk	16[H]
Flammulated Owl	3[H], 4[G], 7[H]
Northern Pygmy-owl	16[H]
Short-eared Owl	3[H], 8[H], 16[H], 25[H]
Northern Saw-whet Owl	5[B], 6[H], 11[H], 23[H], 31[H]
Calliope Hummingbird	S[A]
Hammond's Flycatcher	S[A], 10[B]
Olive-sided Flycatcher	5[B], 10[B]
Steller's Jay	5[B]
Red-breasted Nuthatch	3[A], 8[A], 31[A]
White-breasted Nuthatch	5[B]
Golden-crowned Kinglet	S[A]
Ruby-crowned Kinglet	10[B]
Water Pipit	5[B]
Solitary Vireo	5[B]
Orange-crowned Warbler	23[A]
Nashville Warbler	S[A]
Lincoln's Sparrow	5[B], S[A]
White-crowned Sparrow	10[B]
Himalayan Snowcock	S[A]

[A]Alcorn (1988). [B]Behle (1978). [G]S. Dunham (unpublished data from breeding bird surveys in 1993). [H]Herron et al. (1985)

(1988), and S. Dunham (unpublished data from breeding bird surveys in 1993).

POPULATION SOMEWHERE LARGE?—The other component to the relative rarity of a species is its local abundance. This variable is used regularly in rarity studies and generally is used subjectively, often because detailed numbers are not available (Rabinowitz et al. 1986). Because of this, I use it subjectively as well. The definition of "common" varies by taxa. For example, carnivores typically are less common than insectivores at a given site (Brown and Maurer 1987). Therefore, using a single numeric criterion above which a species is considered "common" will result in a systematic bias in vulnerability scores even if no systematic bias exists in susceptibility to extirpation. Therefore, for a given species, if anywhere in the Great Basin there is a population that is "common" for its taxon, I have given the species a score of 0. Data for this assessment came from Ryser (1985), Alcorn (1988), and breeding bird surveys done during the breeding season by myself or my students.

HABITAT SPECIALIZATION.—Habitat specialists (score value = 1) were defined as species that exist in Nevada only in montane habitat. Limited use outside montane habitat, such as

mixed forest or riparian areas, scored .50, and relative generalists were given a value of 0. Data on habitat use came from Ehrlich et al. (1988).

SUSCEPTIBILITY TO COWBIRD PARASITISM.—Although there is extensive literature on the potential effects of Brown-headed Cowbirds (Molothrus ater) on passerine reproduction (e.g., Mayfield 1977, Brittingham and Temple 1983), the problem has been little studied in the Great Basin. Brown-headed Cowbirds are seen at high elevations in the Great Basin (Fleischer and Rothstein 1988, Fleischer personal communication), particularly associated with riparian habitat and human impact, including cattle grazing. Also, cowbirds can range far from foraging areas in order to brood parasitize (Rothstein et al. 1984). However, not all species are susceptible to parasitism from cowbirds, and some parasitized species are unaffected (e.g., precocial species). I scored species based on my expectation of potential impact of cowbird parasitism. Only passerines that are opencup nesters could score above 0; Corvidae received 0. Species known to reject cowbird eggs were given a score of 0. Large hosts that did not eject eggs (larger than a female Brown-headed Cowbird; >39 g; Dunning 1993) were given a value of 0.5. Species that are small and not known to reject eggs were assigned a score of 1. Data came from Friedman (1971), Rothstein (1975), Airola (1986), Marvil and Cruz (1989), and Briskie et al. (1992).

MIGRATORY STATUS.—There is some controversy regarding relative costs of migration versus residency in birds. However, because migrants are dependent on habitats in more than one geographic area, I consider them more vulnerable than nonmigrants. I scored migratory status as no latitudinal migration = 0 (lowest risk), migrates primarily to U.S. = .25, migrates primarily to Middle or South America, winters in nonforest = .50, winters in secondary forest = .75, winters in mature forest = 1.0.

REPRODUCTIVE POTENTIAL.—I considered reproductive potential to be the anticipated ability to recover from a population crash and based it on the first age of reproduction, clutch size, and number of broods within a year (data from Ehrlich et. al. 1988). I classified reproductive potential based on an index. The index was the mean clutch size times the number of

broods in a year, divided by the age of first reproduction. With this index, a species that breeds repeatedly, at an early age, and with large clutches will have a low score. When no data were available for number of broods, one brood was assumed. Age at first breeding was assumed to be one for small birds, unless data from the literature indicated otherwise. The relationships between the index, reproductive potential, and risk value were made arbitrarily and are presented in Table 3. Data and references associated with this calculation for each species can be obtained from the author.

DIET SPECIALIZATION.—Information on diet breadth came from Ehrlich et al. (1988), and species were classified as generalists (score = 0), moderate specialists (0.5), or specialists (1.0) based on diet described there. This assessment was subjective, based on number of food types typically in the diet and foraging method used.

With this system, vulnerability scores could range from 0 to 7, with 7 being the greatest probability of extirpation from the Great Basin. One variable not included in the analysis that is important in biological risk to extirpation was local population trends. Local population trends were omitted because they are generally unknown for nongame birds in the Great Basin. Local endemism should be considered in scoring as well, but the Great Basin has no endemic bird species. Another variable that has been suggested as a risk to survival is ground nesting. Traditional thought places ground nesters at higher risk to predation than off-ground nesters (e.g., Ricklefs 1969, Slagsvold 1982, Collias and Collias 1984). However, in a reanalysis of the data, Martin (1993) found that ground nesters were not disproportionately susceptible to depredation. Given this important ambiguity, nest location was omitted from the analysis.

RESULTS AND DISCUSSION

There were 41 additions of various mountain ranges to breeding bird distributions (Table 2). The 74 breeding bird species used in this analysis, their associated scores for each life-history trait, and their vulnerability scores are listed in Table 4. Taxonomy follows the convention of the American Ornithologists' Union (1983). Vulnerability scores ranged from 0.60 for the American Robin (scientific names are

TABLE 3. Reproductive potential and its relationship to risk score. The index is mean clutch size times the number of broods in a year, divided by the age of first reproduction.

Index value	Reproductive potential	Risk score
<1.5	very low	1.0
1.5–2.9	low	0.75
3–5.9	medium	0.50
6–11.9	medium-high	0.25
>11.9	high	0

found in Table 4) to 5.70 for the Olive-sided Flycatcher and Painted Redstart. None of the variables alone was sufficient to assess vulnerability to extirpation. This has been seen by others (e.g., Burke and Humphrey 1987) and is due to other life-history factors affecting susceptibility to extirpation (Arita et al. 1990). Therefore, range and density estimates alone cannot be used to assess vulnerability to extirpation. Another problem with using range and density as the only criteria for extirpation risk is that slice-in-time assessments of rarity can give misleading results due to natural fluctuations in distribution and population size (Hanski 1985). Species' ranges expand and contract, and population densities can undergo large fluctuations annually, even in long-lived species such as birds. Therefore, being uncommon does not, de facto, make a species vulnerable to extirpation; in contrast, being common does not assure continued presence (e.g., the Passenger Pigeon [*Ectopistes migratorius*]; Bucher 1992).

Passerines tended to rank as more susceptible to extirpation than other orders, primarily because one threat, vulnerability to cowbird parasitism, did not impact non-passerines. Unlike some earlier studies of birds (Terborgh and Winter 1980, Kattan 1992), I found no taxonomic pattern in susceptibility to extirpation. The 10 species with the highest vulnerability score come from seven families in four orders. There are several likely explanations for this. The first is that no inherent patterns exist. Alternatively, a true taxonomic pattern in extirpation proneness might exist for Great Basin birds but was missed because of incomplete data, because of a subsampling effect (not enough of the Great Basin surveyed), or because the analysis considers only current species (implying that extirpation-prone species are gone).

Many species with similar or identical vulnerability scores were vulnerable for different

TABLE 4. Data used in analyses and vulnerability scorings; variable definitions given in text. Higher values indicate higher susceptibility to extirpation from the Great Basin.

Species	Vulner-ability score	Range	Some-where large?	Habitat special-ization?	Cowbird problem?	Migratory status	Reproductive potential	Diet special-ization
Canada Goose								
(Branta canadensis)	1.90	.90	0	0	0	.25	.75	0
Green-winged Teal								
(Anas crecca)	2.90	.90	1	.5	0	.25	.25	0
American Wigeon								
(A. americana)	2.90	.90	1	.5	0	.25	.25	0
Canvasback								
(Aythya valisineria)	2.90	.90	1	.5	0	.25	.25	0
Sharp-shinned Hawk								
(Accipiter striatus)	4.00	.50	1	.5	0	.75	.75	.5
Northern Goshawk								
(A. gentilis)	3.10	.60	1	.5	0	.25	.75	0
Himalayan Snowcock								
(Tetraogallus himalayensis)	4.20	.95	1	1	0	0	.75	.5
Blue Grouse								
(Dendragapus obscurus)	2.75	.50	0	1	0	0	.25	1
Ruffed Grouse								
(Bonasa umbellus)	3.20	.95	1	1	0	0	.25	0
Mountain Quail								
(Oreortyx pictus)	1.90	.65	0	1	0	0	.25	0
Common Snipe								
(Gallinago gallinago)	2.70	.70	1	0	0	.50	.50	0
Flammulated Owl								
(Otus flammeolus)	3.05	.55	0	1	0	.50	.50	.5
Northern Pygmy-owl								
(Glaucidium gnoma)	3.30	.80	1	1	0	0	.50	0
Short-eared Owl								
(Asio flammeus)	2.55	.80	1	0	0	.25	.50	0
Northern Saw-whet Owl								
(Aegolius acadicus)	2.85	.60	0	1	0	.25	.50	.5
Common Nighthawk								
(Chordeiles minor)	2.10	.35	0	0	0	.50	.75	.5
Whip-poor-will								
(Caprimulgus vociferus)	4.70	.95	1	0	0	1	.75	1
Calliope Hummingbird								
(Stellula calliope)	3.15	.65	0	.5	0	.75	.75	.5
Broad-tailed Hummingbird								
(Salasphorus platycercus)	2.30	.05	0	.5	0	.50	.75	.5
Lewis' Woodpecker								
(Melanerpes lewis)	1.90	.90	0	.5	0	.25	.25	0
Yellow-bellied Sapsucker								
(Sphyrapicus varius)	2.55	.30	0	.5	0	.75	.50	.5
Red-breasted Sapsucker								
(S. ruber)	3.15	.85	0	.5	0	.75	.50	.5
Williamson's Sapsucker								
(S. thyroideus)	3.35	.55	0	1	0	.75	.50	.5
Downy Woodpecker								
(Picoides pubescens)	2.10	.60	0	.5	0	0	.50	.5
Hairy Woodpecker								
(P. villosus)	2.00	0	0	.5	0	0	.50	1
White-headed Woodpecker								
(P. albolarvatus)	3.45	.95	1	1	0	0	.50	0
Black-backed Woodpecker								
(P. arcticus)	4.45	.95	1	1	0	0	.50	1
Three-toed Woodpecker								
(P. tridactylus)	4.45	.95	1	1	0	0	.50	1
Olive-sided Flycatcher								
(Contopus borealis)	5.70	.45	1	1	1[a]	.75	.50	1
Hammond's Flycatcher								
(Empidonax hammondii)	5.45	.70	1	1	1[a]	.75	.50	.5
Dusky Flycatcher								
(E. oberholseri)	3.30	.05	0	.5	1	.75	.50	.5
Western Flycatcher								
(E. difficilis)	3.95	.45	0	.5	1	1	.50	.5
Horned Lark								
(Eremophila alpestris)	2.60	.85	0	0	1	.25	.50	0

TABLE 4. Continued.

Species	Vulner-ability score	Criteria						
		Range	Some-where large?	Habitat special-ization?	Cowbird problem?	Migratory status	Reproductive potential	Diet special-ization
Violet-green Swallow								
(*Tachycineta thalassina*)	3.00	0	0	1	0	.50	.50	1
Gray Jay								
(*Perisoreus canadensis*)	2.95	.95	1	.5	0	0	.50	0
Steller's Jay								
(*Cyanocitta stelleri*)	2.10	.60	0	1	0	0	.50	0
Clark's Nutcracker								
(*Nucifraga columbiana*)	1.65	.15	0	1	0	0	.50	0
Mountain Chickadee								
(*Parus gambeli*)	1.50	0	0	1	0	0	0	.5
Red-breasted Nuthatch								
(*Sitta canadensis*)	2.15	.40	0	.5	0	.25	.50	.5
White-breasted Nuthatch								
(*S. carolinensis*)	2.10	.10	1	.5	0	0	0	.5
Pygmy Nuthatch								
(*S. pygmaea*)	1.95	.70	0	.5	0	0	.25	.5
Brown Creeper								
(*Certhia americana*)	1.65	.40	0	.5	0	.25	.50	0
American Dipper								
(*Cinclus mexicanus*)	3.25	.50	1	1	0	0	.25	.5
Golden-crowned Kinglet								
(*Regulus satrapa*)	2.40	.65	0	.5	1	.25	0	0
Ruby-crowned Kinglet								
(*R. calendula*)	2.65	.15	0	.5	1[a]	.75	.25	0
Western Bluebird								
(*Sialia mexicana*)	2.55	.80	1	0	0	.25	.50	0
Mountain Bluebird								
(*S. currucoides*)	1.60	.10	0	.5	0	.25	.25	.5
Townsend's Solitaire								
(*Myadestes townsendi*)	3.00	.25	0	1	1	.25	.50	0
Veery								
(*Catharus fuscescens*)	4.90	.90	1	.5	1[a]	.50	.50	.5
Swainson's Thrush								
(*C. ustulatus*)	3.60	.60	0	.5	1[a]	.50	.50	.5
Hermit Thrush								
(*C. guttatus*)	2.55	.05	0	.5	1[a]	.75	.25	0
American Robin								
(*Turdus migratorius*)	0.60	.10	0	0	0	.25	.25	0
Water Pipit								
(*Anthus spinoletta*)	3.65	.90	0	1	1[a]	.25	.50	0
Solitary Vireo								
(*Vireo solitarius*)	3.55	.30	0	.5	1	1	.25	.5
Orange-crowned Warbler								
(*Vermivora celata*)	2.60	.35	0	0	1	.75	.50	0
Nashville Warbler								
(*V. ruficapilla*)	4.15	.90	0	.5	1[a]	.75	.50	.5
Virginia's Warbler								
(*V. virginiae*)	3.25	.25	0	.5	1[a]	.75	.25	.5
Yellow-rumped Warbler								
(*Dendroica coronata*)	2.30	.05	0	.5	1	.50	.25	0
Grace's Warbler								
(*D. graciae*)	4.05	.80	0	1	1[a]	.50	.25	.5
MacGillivray's Warbler								
(*Oporornis tolmiei*)	3.35	.35	0	.5	1[a]	.50	.50	.5
Wilson's Warbler								
(*Wilsonia pusilla*)	3.85	.85	0	.5	1	.50	.50	.5
Painted Redstart								
(*Myioborus pictus*)	5.70	.95	1	1	1[a]	.75	.50	.5
Western Tanager								
(*Piranga ludoviciana*)	3.15	.15	0	.5	1[a]	1	.50	0
Green-tailed Towhee								
(*Pipilo chlorurus*)	1.75	0	0	0	1[a]	.50	.25	0
Fox Sparrow								
(*Passerella iliaca*)	1.95	.45	0	0	1	.25	.25	0
Lincoln's Sparrow								
(*Melospiza lincolnii*)	4.60	.85	1	1	1[a]	.50	.25	0

TABLE 4. Continued.

Species	Vulner- ability score	Criteria						
		Range	Some- where large?	Habitat special- ization?	Cowbird problem?	Migratory status	Reproductive potential	Diet special- ization
White-crowned Sparrow (*Zonotrichia leucophrys*)	2.00	.50	0	0	1	.25	.25	0
Dark-eyed Junco (*Junco hyemalis*)	2.05	.05	0	.5	1	.25	.25	0
Gray-crowned Rosy Finch (*Leucosticte tephrocotis*)	3.70	.95	0	1	1[a]	.25	.50	0
Black Rosy Finch (*L. atrata*)	3.50	.75	0	1	1[a]	.25	.50	0
Cassin's Finch (*Carpodacus cassinii*)	2.50	0	0	1	1[a]	.25	.25	0
Red Crossbill (*Loxia curvirostra*)	3.15	.40	0	.5	1[a]	.25	.50	.5
Pine Siskin (*Carduelis pinus*)	2.40	.40	0	.5	1[a]	.25	.25	0
Evening Grosbeak (*Coccothraustes vespertinus*)	2.35	.85	0	.5	.5[a]	.25	.25	0

[a]Assumed to not eject Brown-headed Cowbird eggs

suites of threats to persistence. That is, some equal scores were made up of low values for one or more characteristic and corresponding-ly high values for other traits, which balanced in the ranking. This observation is consistent with Rabinowitz's (1981, Rabinowitz et al. 1986) observations of plant species' rarity in Great Britain. It should be noted that this analy-sis refers to species loss in the Great Basin and does not reflect species-wide vulnerability.

This type of analysis is sensitive to the num-ber of variables included. Adding or deleting characters from the analysis would change scores. For example, if ground nesting were decisively shown to increase vulnerability, it could be added to the analysis and would change relative scores. Results also would be altered if the characteristics were weighted differently. I did not weight any variable as more impor-tant than another because of the lack of data that demonstrates the validity of weighting particular traits over others. Arbitrarily assign-ing different weights in the absence of inde-pendent data supporting the weighting would result in unwarranted bias in the vulnerability scores.

The results presented are not absolute rank-ings for susceptibility to extirpation because data are incomplete and more threats might become apparent, which would have to be added to the analysis. Validity of these results depends entirely on reliability of the data used and how representative the 20 mountain ranges are of the rest of the Great Basin. There is a dearth of distributional and life-history data

on many Great Basin birds. Therefore, my results should be taken as a guide for detailed local studies of species and their surrounding communities. Results of these studies can then be used to develop proactive manage-ment plans.

Vulnerability Ranks and Management

Vulnerability to extirpation and manage-ment priorities are not equal. Scores based strictly on biological variables ignore homo-centric values, such as hunting or local tradi-tional uses. For example, the top 10 vulnerable species in this analysis include only one hunt-ed species (an introduced one at that), though others were scored. In addition, how a given rank comes about can affect management pri-orities. There are four ways a species can have a high score, and they should be interpreted differently for management.

(a) High score occurs when the Great Basin is within the greater bounds of a species' dis-tribution and local declines have reduced a species' range and population sizes in the Great Basin. These species are probably declining because of local problems, and in this analysis might include Mountain Quail and Northern Goshawk. Specific management plans should be enacted to increase population numbers, sizes, and distributions.

(b) High score occurs when the Great Basin is within the greater bounds of a species' distri-bution, and the species is declining through-out its range. Problems could be occurring on the breeding grounds, wintering grounds, or

migratory routes. If the cause of decline is known and can be improved through local management, then this should be done. If the cause of the decline is known, but occurs outside the Great Basin, then I would recommend monitoring populations but not making any management efforts. If the cause of the decline is not known, as for many Neotropical migrants, gather information to determine whether or not local management could improve local or region-wide population conditions. If management efforts are suspected to work, implement them with proper controls and follow-up work. If no effect is found, discontinue management.

(c) High score occurs partly because the Great Basin is at the edge of a species' distribution, thus limiting its local distribution and population sizes. Of the top 10 scored species in this analysis, five have Nevada as part of their distributional boundary. This is possibly the trickiest category for management. Species' ranges fluctuate, and population declines might be range retractions having nothing to do with local conditions. These species should be monitored because range retraction might be an early indicator of a species-wide decline (e.g., Laymon and Halterman 1987). However, it can also indicate local problems that require local management solutions. These species need further investigation.

(d) High score occurs when species has declined severely (thus reducing its range and commonness) but is recovering. Continue existing management efforts, if any, and monitor populations to make sure recovery continues. If it does not, these species belong in one of the other three sub-categories.

In all instances involving management plans, efforts should be made to set up proper studies or experiments to ascertain the limiting factor(s) and the correct method(s) for counteracting the problem (MacNab 1983, Gavin 1989, 1991, Murphy and Noon 1992). This includes monitoring suitable control sites. Without using adequate experimental design, it will not be possible to ascertain the effectiveness of management efforts. Low-score species should still be monitored and management plans developed. Low-score species are those that are closest to recovery or those not threatened and thus have potential for the quickest success from management.

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